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(54) EXTRUSION OF MAGNESIUM ALLOY AT HIGH SPEED

(71) We, DOW CHEMICAL COMPANY, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of Midland, County of Midland, State of Michigan, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention concerns extruding at high speed a magnesium base alloy containing aluminum, manganese and optionally zinc.

The A.S.T.M. designated AZ31B magnesium base alloy containing from 2.5 to 3.5 percent aluminum, at least 0.2 percent manganese, and from 0.7 to 1.3 percent zinc, has been used successfully for many years in the extruded form but can only be extruded normally at a rate of less than 40 feet per minute (12 m./min.) without hot shorting (cracking in the hot forming stage). For example, a magnesium base alloy containing 2.7 weight percent aluminum, 0.97 weight percent zinc and 0.44 weight percent manganese when extruded at 900°F. (480°C.) has an extrusion speed limit of about 35 fpm (10.5 m./min.) due to hot shorting. It would be very desirable to obtain extrusion speeds in such an alloy system of 100 fpm (30 m./min.) or more.

Accordingly, the present invention provides a process comprising extruding at high speed a magnesium base alloy without appreciable deleterious effect on mechanical properties.

In accordance with the present invention, it has been found that the above advantages can be obtained by extruding at high speed, e.g. 70 fpm (21 m./min.), preferably about 100 fpm (30 m./min.) or more, a magnesium base alloy containing, by weight, from 1.9 to 3.5 percent aluminum, from 0 to 0.6 percent zinc, and from 0.2 to 1.5 percent manganese, the balance being magnesium together with normal impurities. Best results are usually obtained when the alloy is extruded at a temperature of about 900°F. (480°C.).

Preferably the alloy employed will contain from 1.9 to 3.0 percent of the aluminum, from 0.2 to 0.5 percent of the zinc, and from 0.2 to 1.0 percent of the manganese.

In preparing the alloys, conventional alloying and melting techniques, as practiced by those skilled in the art, can be employed, using alloying and base metal constituents containing the normal amounts and types of impurities.

The following examples illustrate the present invention.

EXAMPLES 1—12

Various magnesium base alloys were made into permanent mold ingots (PM) or direct chill (DC) casts, samples were then extruded at 900°F. (480°C.) at a 150 to 1 reduction in cross-sectional area below hot short speeds into 1/16" × 3/4" (1.6 × 19 mm.) strips and tested for strength properties and corrosion rates. Corrosion specimens were exposed from 7 to 14 days in a standard alternate immersion test (3 percent NaCl for a 1/2 minute immersion and 2 minute drying cycle).

Table I gives the results of the strength and corrosion tests on various magnesium-aluminum-zinc-maganese alloys within the present invention. The comparative example was prepared from a pre-extruded billet (Pre-Ext) of commercial AZ31B.

The data of Table I shows that alloys of the present invention have extrusion speeds at least double that of AZ31B and in most cases increased to at least 100 feet per minute (30 m./min.). Moreover, mechanical properties are not significantly affected. Where corrosion resistance is required, the zinc content should be at least about 0.2 percent. In other applications of the present alloy corrosion considerations may not be important. Thus the disclosed novel alloy system yields significant improvement in the extrusion speed while maintaining mechanical properties comparable to AZ31B.

TABLE I

Example No.	Composition*			Cast**	Extrusion Speed		Corrosion Rate		Kg./cm.²		
	% Al	% Zn	% Mn		fpm	m./min.	Mg/cm²/day	% E	TYS	CYS	TS
Comparative	2.7	0.97	0.44	Pre-Ext.	30	9	0.5	12	1680	840	2450
1	2.9	0.53	0.53	PM	70	21	0.6	12	1610	910	2450
2	2.8	0.40	0.45	DC	100	30	0.6	9	1680	980	2520
3	2.9	0.38	0.44	DC	100	30	0.8	9	1680	910	2450
4	2.8	0.38	0.42	DC	100	30	0.9	10	1680	980	2590
5	2.7	0.36	0.46	DC	100	30	0.6	10	1680	980	2520
6	2.8	0.22	0.51	PM	100	30	0.7	12	1540	840	2380

* balance magnesium
** values of properties of DC cast alloys measured on center sections
E = Elongation
TYS = Tensile yield strength
CYS = Compression yield strength
TS = Tensile strength

Table II represents the results of strength tests on two magnesium-aluminum-manganese alloys made into permanent mold ingots and extruded at 100 fpm (30 m./min.) according to the present invention.

Example No.	Composition*		Extrusion Temperature °F	Kg./cm²			
	% Al	% Mn		% E	TYS	CYS	TS
7	2.9	0.92	900	11	1610	910	2380
8	1.9	1.01	900	9	1680	840	2450

*balance essentially magnesium

Example 13

Pre-extruded billets of AZ31B and DC cast alloys of the present invention, having a nominal composition of 3.0 percent aluminum, 0.45 percent manganese, and 0.4 percent zinc, the balance being essentially magnesium, were extruded through a spider die into 1/2" O.D. × 1/16" (12.7 mm. outside diameter × 1.6 mm.) wall tubing. Maximum extrusion speeds without hot shorting are shown below for several die temperatures:

Extrusion Speed

Example No.	at 700°F. (371°C.)		at 760°F. (404°C.)		at 840°F. (449°C.)	
	fpm	m./min.	fpm	m./min.	fpm	m./min.
AZ31B(1)	45	13.5	35	10.5	25	7.5
13	62	18.6(2)	55	16.5(2)	50	15

(1) For Comparison
(2) Extruder Maximum

In the case of the Example 13 alloy at 700°F. (371°C.) and 760°F. (404°C.) the maximum extrusion speeds were due to the mechanical limitations of the extrusion extruder. These mechanical limitations and not the alloys themselves also caused the maximum extrusion speeds to be higher at lower temperatures than at the higher temperatures. Notwithstanding the limitations of the extruder, the data shows an outstanding increase in extrudability of the alloys of the present invention over conventional AZ31B alloy. Moreover, even with the more complex extrusion and the lower temperatures, the lower zinc content (as compared to that of AZ31B) resulted in substantial increases in extrusion speeds at each temperature over the conventional AZ31B alloy.

By the term " high speed ", when applied to the rate of extrusion of the alloy of the present invention in the present specification, is meant a speed greater than the maximum extrusion rate of conventional A.S.T.M. designated AZ31B magnesium base alloy consistent with good mechanical properties i.e. 40 feet per minute.

WHAT WE CLAIM IS:—

1. A process which comprises extruding at high speed a magnesium base alloy containing, by weight, from 1.9 to 3.5 percent aluminum, from 0 to 0.6 percent zinc, from 0.2 to 1.5 percent manganese, and the balance magnesium together with normal impurities.

2. A process according to Claim 1 wherein the alloy is extruded at a speed of at least 70 fpm (21 m./min.).

3. A process according to Claim 1 wherein the alloy is extruded at a speed of 100 fpm (30 m./min.).

4. A process according to any one of Claims 1 to 3 wherein the alloy is extruded at a temperature of from 840°F to 900°F. (480°C.).

5. A process according to any one of Claims 1 to 4 wherein the amount of aluminum present in the alloy employed is from 1.9 to 3.0 percent.

6. A process according to any one of Claims 1 to 5 wherein the amount of manganese present in the alloy employed is from 0.2 to 1.0 percent.

7. A process according to any one of Claims 1 to 6 wherein the amount of zinc present in the alloy employed is from 0.2 to 0.5 percent.

8. A process according to Claim 1 substantially as described hereinbefore with reference to any one of the Examples.

9. Extruded articles of magnesium base alloys whenever produced by the process of any one of the preceding claims.

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